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Fix nozzle elevations and orientations for distillation columns

An engineering, procurement and construction (EPC) contractor receives a front-end engineering design (FEED) package or basic design and engineering package as an input document from the owner. The information about the process equipment covered in these packages is provided in the form of equipment data sheets. Distillation columns data sheets cover a column line sketch with configuration, the type of internals/trays, the number of trays, and process related details like vapor-liquid hydraulic parameters, properties, etc. The column sketch also covers nozzle connections, with their respective name (purpose), size and indicative locations.

Nozzle connections are broadly categorized into four types: process, safety, instrumentation and inspection/maintenance.

In general, process licensors only provide details of process nozzles that are important to column operation and performance (e.g., feed inlet connections, furnace feed, reboiler feeds). For such connections, elaborate details are provided with internal arrangements, elevation, location and suggested orientation. Other types of nozzle connections and elevations are provided as indicative and their details are left to the detail engineering team.

If the engineering team does not have an internals expert, design engineers normally keep such details under hold. These details are later filled in by the tray designer/supplier. Trays are short delivery items compared to columns, which are required at the site much later and are ordered late in the sequence, putting column fabricator engineering work on hold. This sometimes results in delays by the column vendor or a requested cost escalation.

This article provides an explanation of each type of column nozzle and logic, while fixing nozzle elevation and orientations—accompanying sketches (figures) are provided. The most preferred positions are shown here, as well as alternate options. Using these guidelines, column and piping engineers can perform this work by themselves.

The details discussed here are primarily for sieve and valve trays, which are the most common type of distillation column hardware used in the process industries. The details may also apply for bubble cap trays with some modifications, but may not apply to proprietary trays/internals. Information for these trays/internals should be obtained from their respective designers/suppliers.

Feed nozzles. As shown in **FIG. 1,** a typical distillation column feed is a two-phase (vapor and liquid) flow from a furnace (e.g., crude or vacuum columns). To separate liquid from vapor, special internals—such as a vapor horn with tangential entry (single or double), shown in **FIG. 1A**—are used. These internals uniformly distribute vapor across the diameter. In the case of pressure-sensitive systems like vacuum columns, proprietary internals such as a Schopetentoeter (**FIG. 1B**) or similar are used.

Reboiler nozzles are normally kept flush to the column wall and do not have any internal attached. If the nozzle is located close to liquid levels or directly opposite the bottom downcomer or seal pan, an internal baffle like the one shown in **FIG. 1C** is suggested. All types of feed nozzles require sufficient space above and below the feed. This serves three purposes:

- Avoids disturbing the bottom liquid level
- Avoids the impact of the two phases on the trays or packed bed above
- Distributes vapor across the diameter and knock out liquid.

The details of such feed nozzles and internals are provided in the licenser's data sheet.

Reflux nozzles. Reflux liquid is supplied on the top tray. The feed location is kept opposite the respective tray downcomer in an un-perforated area. Normally, the

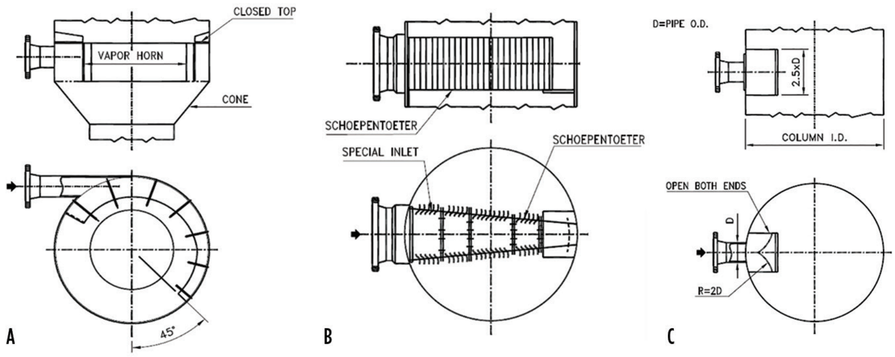


FIG. 1. Feed nozzle with vapor horn (1A), feed inlet with Schoepenteoter (B) and feed inlet deflector baffle (C).

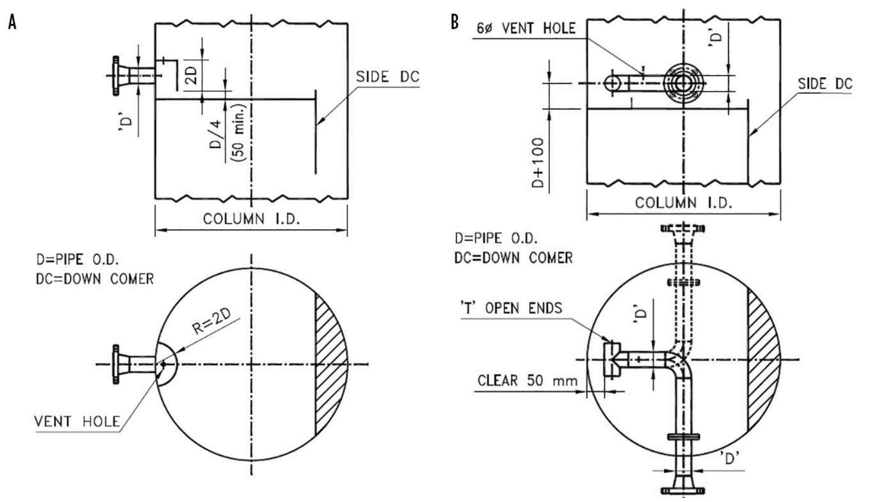


FIG. 2. Reflux inlet one-pass trays.

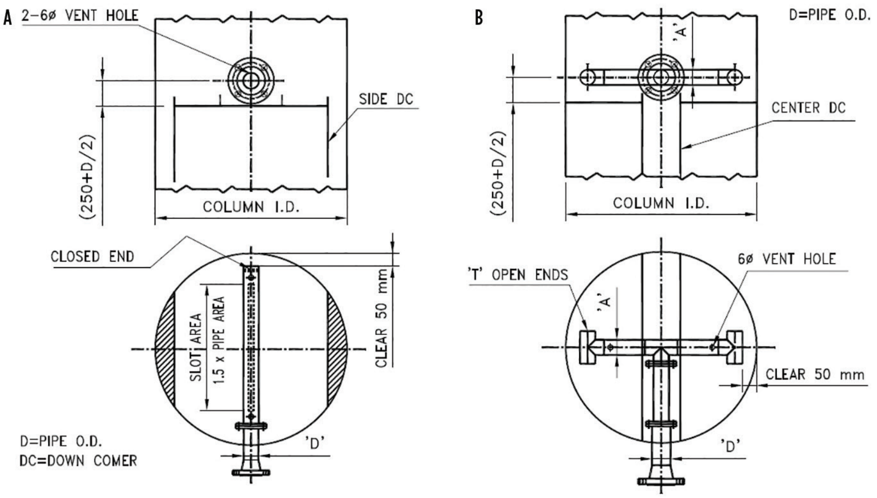


FIG. 3. Reflux inlet two-pass tray, side downcomer (A); and reflux inlet two-pass tray, center downcomer (B).

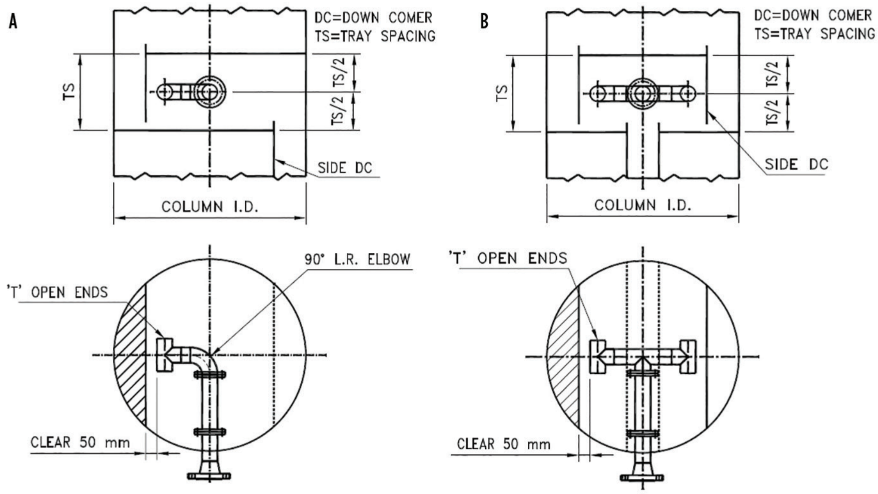


FIG. 4. Intermediate feed one-pass tray (A), and intermediate feed two-pass tray (B).

top tray has an inlet weir height of 100 mm to hold the liquid back and distribute it uniformly over the tray active area flowing over the weir.

FIG. 2 shows the details of a reflux inlet, one-pass tray. For a single-pass tray, **FIG. 2A** is preferred. The internal baffle is made of a half-cut pipe with a bottom gap, as shown. Due to piping orientation, if following **FIG. 2A** is not possible, an internal pipe distributor can be provided as per **FIG. 2B.** This provides the flexibility of fixing the nozzle at any orientation. The reflux nozzle's elevation is kept just above liquid level on the tray to avoid liquid splash from a height.

FIG. 3 shows details of reflux inlet nozzles for two-pass trays. For a side downcomer tray, liquid is fed into the central trough (**FIG. 3A**). For a center downcomer tray, the liquid is fed at two extreme opposites to the downcomers (**FIG. 3B**). In this case, the nozzle elevation is also kept close to the tray liquid level.

Intermediate feed nozzles.

The intermediate feeds can be a mix of liquid and vapor or pure vapor. If the feed is only vapor, it can be provided below the active area of the desired tray. Elevation is kept close to the tray level mixing feed vapor-to-vapor zone within the tray spacing. The nozzle is kept about 200 mm–300 mm below the tray.

For intermediate mixed feed (vapor and liquid), arrangements such as those shown in **FIG. 4** are used. Here, the mixture is fed close to the tray downcomer, using equal 'T' as shown. Normally, a clearance of 50 mm is recommended between the tray downcomer and 'T.' With a mixed feed, the elevation is fixed higher than the tray liquid level—good practice is approximately half of the tray spacing. Internal pipe orientation can be routed to the suitable nozzle location determined by a piping engineer.

Manholes.

Manholes (**FIGS. 5A** and **5B**) are required for regular inspection of trays and carrying out maintenance work. Nozzle elevations are fixed so that bottom line of the nozzle is at least 100 mm above the tray level. This avoids injuries to an operator from tray studs and other projections while entering. A comfortable and appropriate place for a manhole is in the middle of the tray spacing. Manhole orientation should be arranged so access always opens up in an active area and does not clash with any downcomers or other internals.

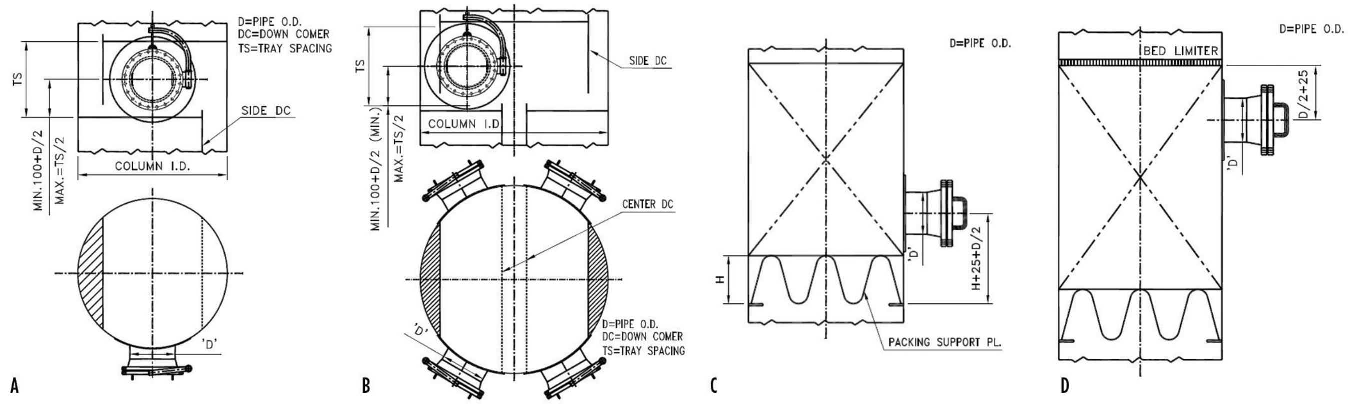


FIG. 5. Manhole one-pass tray (A), options for manhole locations in a two-pass tray (B), a hand hole at the bottom of a packed bed (C) and a hand hole at the top of a packed bed (D).

Fixing the orientation of a manhole in chimney trays and high-quality distributor locations is tricky work. It must be ensured that no chimney riser of a liquid distributor trough is blocking the entry passage.

Hand holes. Hand holes (**FIGS. 5C** and **5D**) are provided mostly in randomly packed towers and are used for either topping up of random packing or removal of packing. Recommended hand hole sizes range from 150 mm–250 mm, depending on column diameter and packing size. For packing removal, hand holes should have a minimum 25-mm gap between the top of the packing support plate and the hand hole inner diameter. Similarly, for topping up of packing, the location should be 25 mm below the bed limiter from the top of the hand hole inner diameter, as shown in **FIG. 5D.**

Pressure and temperature connections. Pressure measurement connections (**FIG. 6**) are always provided in the vapor phase, as most of the pressure measurement instruments work in single phase. The nozzles for pressure measurement are recommended below the active tray area with a minimum gap of 100 mm.

Temperature measuring nozzles are normally provided in the liquid zone due to better heat transfer in the liquid phase. The recommended practice is to provide these nozzles 50 mm above the respective tray. In the case of bubble cap trays, the thermowell is suitably located so it does not clash with the bubble cap.

A thermowell can also be provided in the downcomer area as shown, depending on the available width in the downcomer.

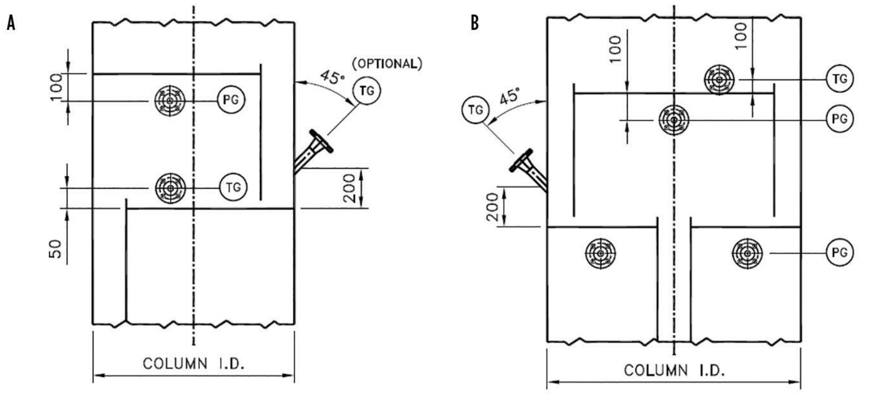


FIG. 6. Pressure and temperature tapping locations in a one-pass tray (A), and pressure and temperature tapping locations in a two-pass tray (B).

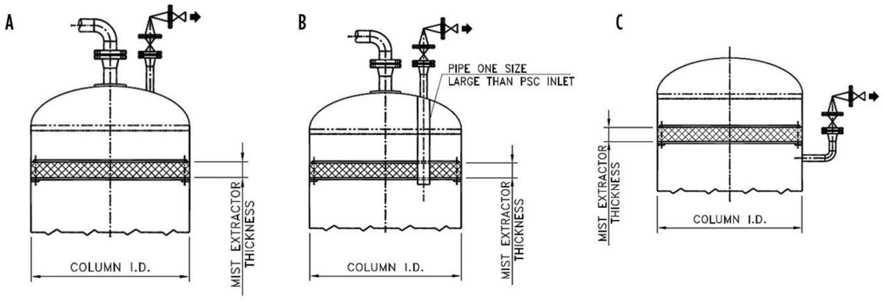


FIG. 7. Safety valve locations options 1 (A), 2 (B) and three (C).

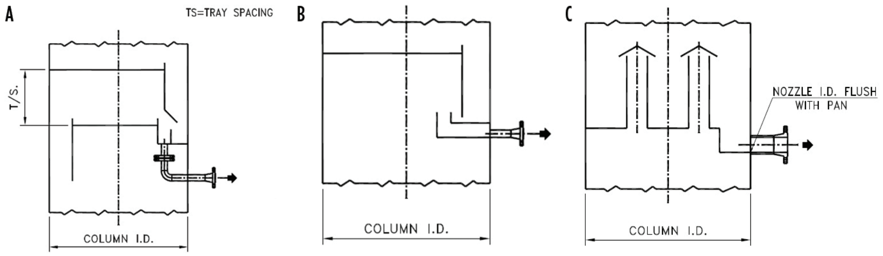
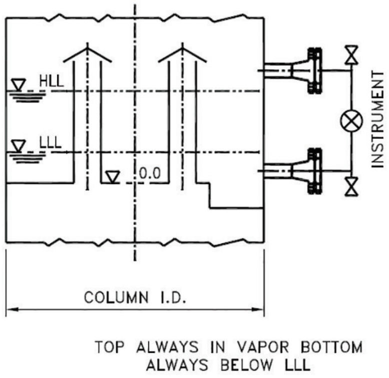


FIG. 8. Partial withdrawal from the tray (A), partial withdrawal from the bottom seal pan (B) and total product withdrawal from the chimney tray (C).

If the width is short and cannot accommodate thermowell projection, it can be made inclined, as shown in **FIG. 6.**

In a distillation column, fixing nozzles elevation and orientation are based on fixed guidelines. This knowledge helps design engineers shorten the engineering and procurement cycle.

Safety valves (pressure relieving devices). Safety valves are normally provided on the top of the vessel or column (**FIG. 7**). Normally, the column/vessel has a mist extractor in the top section. Under pressure surges where chances exist of dislodgement of the mist extractor and choking of the safety valve inlet, a good engineering practice is to provide a pipe sleeve larger than the safety valve inlet size and pass it through the mist extractor (**FIG. 7B**). Under fouling service conditions, it is good engineering practice to provide a safety valve connection below the mist extractor (**FIG. 7C**).



TOP ALWAYS IN VAPOR BOTTOM ALWAYS BELOW LLL

FIG. 9. Level measurements, chimney tray.

Liquid withdrawal nozzle connections. In a distillation column, partial or total liquid withdrawal from the tray is a regular requirement. **FIG. 8A** shows details of a partial liquid withdrawal from the tray by providing a recessed seal pan and inlet weir as a downcomer seal. Partial withdrawal from the lowest trays can be accomplished by providing a seal pan with a draw-off pan (**FIG. 8B**). Here, the nozzle is kept flush with the draw-off pan level.

For the total withdrawal of liquid, a collector (chimney tray) is normally provided, as shown in **FIG. 8C.** The nozzle elevation is kept flush with the recessed pan. Such trays require zero leaks and are generally seal welded.

Level measuring instruments. Most of the instruments in this category are level gauge, level transmitter/controller, level switches, etc. (**FIG. 9**). Normally, each of these instruments has two connections: top and bottom. Depending on instrument selection, these can be arranged side-side, side-bottom, top-bottom, etc. Before fixing the elevation and orientation of such nozzles, the operating level, alarm level or shutdown levels of each situation must be obtained from the process engineer. The top connection of the instrument must always be above the highest liquid level (HLL) in vapor phase, while the bottom connection must always be below the lowest liquid level (LLL). The elevation of each instrument must be determined based on the operating levels and shutdown or alarm levels. If the tray has a recessed pan, as shown in **FIG. 9,** the advantage of seal pan depth can be taken to have a wider operating range.

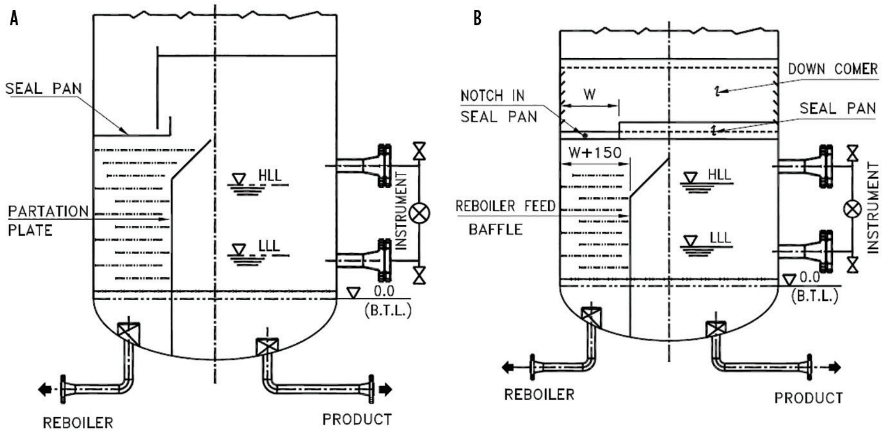


FIG. 10. A reboiler feed baffle in a one-pass tray (A), and a reboiler feed baffle in a two-pass tray (B).

Level control instruments in a reboiler feed baffle. For thermo-siphon reboilers, the reboiler feed from a distillation column is controlled by a pass partition baffle (**FIG. 10**). The baffle overflow is taken out as product. Baffle height is fixed based on the static head requirement of the reboiler.

In this section, all level instruments and controls are provided in the overflow section, which goes to the bottom product outlet. To fix level instruments in this section, an engineer requires operating levels, alarm levels and shutdown levels. Caution must be taken to provide all these instruments in the product section only. The author noticed a mistake in one case where the sections were reversed.

Sampling connections. Sampling connections are small nozzles sizes ranging from 40 mm–50 mm. Sample collection requirements can be for liquid or vapor; this should be clearly specified in the datasheet. Liquid samplers are placed in the liquid zone, either in the downcomer area or close to the tray level. Vapor collection is done from the vapor zone, mostly from below the tray active area.

Takeaway. With this information about various types of nozzles, their technical requirements and placements, working engineers can apply the given logic and decide for themselves the nozzle elevations and orientation.

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